

Modelling the Organisation of Organisational Change

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Abstract. In a dynamic world organisations have to change often. To enable organisations to change, certain structures and capabilities are needed. As all processes, a change process has to be organised itself. In this paper it is shown how within a formal organisation modelling approach also organisation change processes can be modelled. A generic organisation model (covering both organisation structure and behaviour) for organisational change is presented and formally evaluated for a case study. This model takes into account different phases in a change process considered in Social Science literature, such as unfreezing, movement and refreezing. Moreover, at the level of individuals, the internal beliefs and their changes are incorporated in the model. In addition, a distinction is made between automated and non-automated (more conscious) role behaviour. For the latter case an internal mental model for (reflective) reasoning about expected role behaviour is included in the organisation model.

1 Introduction

Within the literature on Organisation Theory changing organisations play a dominant role [12] [5] [6]. As change processes involve many factors ranging from making the employees aware of changes to come and taking away resistance to change to the design of efficient organisational structures. Changes can concern rather simple processes of slight changes in one or more role descriptions. They may affect only a part of the organisation or practically the whole organisation. Roles or big parts of the organisation may be deleted, new ones created. The realisation of the organisation probably changes, e.g., agents fulfilling other roles than before, agents leaving the organisation, agents joining the organisation [4]. A change may be initiated by the environment or by the organisation itself. The organisation of a change process may involve agents from outside the organisation (e.g., consultation) or from inside. In this paper, the process of (business) organisational change is analysed in more detail. Methods used in this analysis are those of formalisation, simulation and verification. As every business process, the process of organisation change has to be organised in one way or the other. To organise such a change process, a generic organisation model for organisational change is introduced and formalised. This organisation model incorporates both multi-agent co-operation aspects and individual cognitive aspects in the form of the internal mental states (e.g., beliefs) of those involved in the change. In a case study the usefulness of this organisation model for organisational change is evaluated.

2 The Stages in Organisational Change

Given an organisation that needs to undergo change, Lewin [10] states that there are two opposing forces at work: forces that resist the change, and forces that drive towards the newly desired organisation, see Figure 1. For example, imagine a factory producing a certain type of goods. According to the management, there is an overcapacity and the amount of produced goods needs to be decreased by 10%. Therefore, the management decides that a number of employees will be fired. The resisting forces are exercised by the employees fearing they will lose their job and the driving forces come from the management that wants to decrease the amount of produced goods. In general, driving and resisting forces either come from within the (realised) organisation or from the environment.

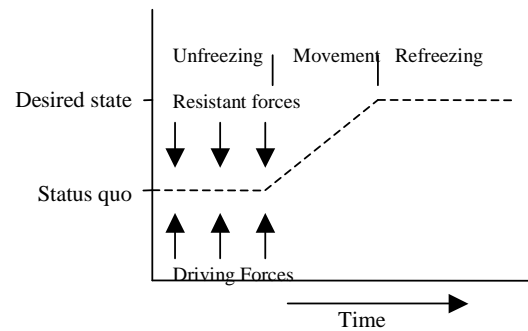


Fig. 1. Movement of an organisation from a status quo to a desired state [12]

Lewin considers the process of organisational change to consist of three stages (see the top part of Figure 1): unfreezing, movement, and refreezing. The unfreezing phase begins at the moment that change becomes necessary and consists of the process of changing the resisting and driving forces in such a way that change becomes possible (i.e., the driving forces outweigh the resisting forces). The actual change of the organisation is contained in the movement phase. The refreezing phase involves freezing the newly formed organisation so that there is no possibility to return to the former status quo or to continue changing in another unwanted direction. The whole re-organisation process is completed when all phases have been completed.

The unfreezing can be done by increasing the driving forces and/or by decreasing the resisting forces. In the case of the production factory increasing the driving forces could, for example, be the management initiating the lay-off procedure for some of the employees, whereas the resisting forces can sometimes be reduced by offering large bonuses to the people that are fired, so that they don't fight the lay-off procedure. Another way of reducing the resisting forces is by explaining the employees why change is necessary and what the new organisation would look like. The unfreezing phase ends when the driving forces outweigh the resisting forces, i.e., when the organisation is ready for the movement to the new organisational form.

The movement phase consists of executing a pre-conceived plan. This plan does not only specify the new organisation structure and behaviour, but also the transition

of responsibilities of old organisation elements to new ones. The refreezing phase consists of the creation of new routines suitable to the new organisation form. Once the organisation settles in its new routines, the organisation gains stability, i.e., is frozen again. In all of the three phases no restriction is placed on the type of organisation, the type of change, consciousness of the organisation with respect to the change, nor on the organisation of organisational change.

3 Organising Organisational Change

The term organising organisational change makes it explicit that organisational change is a behaviour process of that organisation. Therefore, when formalising organisation dynamics, also the process of change must be formally specified as one of the possible ways of behaviour of the organisation. As all organisational behaviour is described in terms of the behaviour properties of the roles in that organisation, also the whole process of organisational change is attributed to a set of roles in that organisation. This section presents an organisation model of organisation change that is based on the three stages of change introduced by Lewin.

3.1 Structure and Informal Behaviour of the Change Organisation

Modelling the forces indicated in Lewin's model entails attributing these forces to roles. Given an existing organisation model that does not model organisation change, there are two basic choices that can be made: assigning these forces to roles already in the model, or extending the model with additional organisational elements. The first can be a part of the second approach by first extending the existing model with additional organisational elements, and then applying the first approach. Although the first approach can be a part of the second, when modelling an organisation in which the realising agents cannot reason about the change or even about the role that they are playing (e.g., when modelling an ant hill), only the first approach can be followed and the roles must be modelled as adaptive roles to ensure the possibility of change. In this article, the realising agents can reason about roles and organisations. The second approach is chosen to most explicitly show the modelling process. In both cases the behavioural specification of the organisation elements needs extension, resulting in an organisation model that incorporates organising organisational change.

Consider, as an example, an organisation modelled as consisting of a number of groups, each consisting of more organisational elements as sketched in the lower part of Figure 2(a). For the representation of the structure of an organisation, the Agent-Group-Role (AGR) modelling approach [1] has been adopted. Let's say that the organisational change concerns the removal of one of the roles in group 1, which in turn might imply that one of the agents realising the organisation will be fired. It might further entail a re-allocation of agents over roles in groups. The organisation in its state before change resists change (resisting forces outweigh the driving forces). To formally model this phenomenon, the resisting and driving forces must be attributed to roles. Attributing them to the existing roles is counterintuitive, because different roles have been identified to specify different behaviours. The resisting and driving

behaviours are of a different category. The way chosen in this article, is to recognise that all agents part of the realisation of the organisation have one thing in common: they are all members of the organisation. Some members of the organisation might be in favour of change, some against, and this might change over time. This is modelled by adding the role Member to the organisation model, and attributing driving and resisting forces to that role. Given that the organisation changes from one stable situation to a new stable situation, there is a need to model the focus existing in the organisational change. For this reason the role of Change Manager is added to the organisational model. The Change Manager is attributed with driving forces. This role can be realised by an agent from an external company, i.e. a consultant type of role, or by an agent from within the organisation. In Figure 2(a), the new roles are grouped together in an organisational element called the Change Group, the members are represented by Member One, Member Two, etc.

The Change Group is depicted in grey in Figure 2(a) to indicate that in stable situations this group is inactive. The Change Manager can be of several different types, for example there can be a global Change Manager, that is allowed to change the entire organisation, but it's also possible to have a local Change Manager that is only allowed to change a certain part within an organisation. Because the Change Manager can be a representative of the company itself or of an external company there is no predefined inter group connection between this role and another. Every realising agent of the organisation is (next to the role it was already allocated to) also allocated to one instance of the Member role of the Change Group. Standard inter group connections between Member roles and the roles allocated to the same agent are added to the organisational model. The Change Group has a meta-view on the organisation, and can, therefore, be seen as a meta-group. The start of an unfreezing phase (meaning a change is due) is characterised by a sudden activity of the Change Manager within the Change Group. The Change Manager might, for example, inform (all or some of) the instances of the Member role of the impending organisational change and the reasons for this change. Aside from the resulting reduction of resisting forces that this information might bring about, this interaction can also be used to model the preparation for the movement phase.

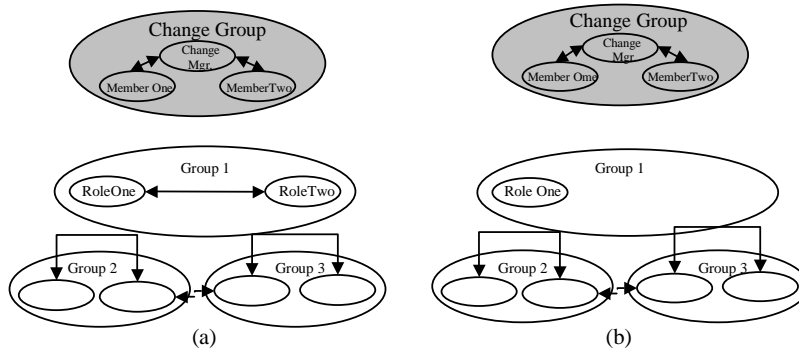


Fig. 2. (a) An organisation before the change; the Change Group is inactive
(b) Organisation after the organisation change

At the end of a well-performed unfreezing stage, maybe all Member role instances, but at least every Member role instance whose realising agent is somehow involved in the change, now has beliefs about which role its realising agent may have to play in the new organisation. These beliefs include the expected role behaviour. The end of the unfreezing phase may be characterised by the presence of these beliefs in the respective member role instances or communication of this presence to the Change Manager.

The start of the movement phase, after a well-performed unfreezing phase, is characterised by the Change Manager informing all Members of when the actual change in organisation is to take place. At the indicated moment, all Member roles are to consider in their beliefs the new organisation form to be the current organisation form. The movement phase is used to achieve (for example, by being informed) that all involved will get the appropriate beliefs on the new structure and their roles in this structure. As a result, the affected parts of the organisation will start behaving according to the behaviour specification of the new organisation form. This process is modelled by the inter group connections between Member roles and roles of the new organisation form. Behaviour that has become obsolete because of the deletion of parts of the organisation will not occur any longer.

The start of the refreezing phase is characterised by regular functioning of the new organisation form and a de-activation of the Change Group, see Figure 2(b). The refreezing phase is complete when the behaviour of the organisation shows the routines that correspond to the expected behaviour of the new, now current, organisation.

Next to the structural properties of the organisation model of organisational change, also the behavioural properties of the roles involved should be described to get a complete model. The next sections describe the behavioural properties of the main roles; the Change Manager and the Member.

3.2 Dynamic Properties for the Behaviour of the Change Organisation

The Change Manager is active in all stages of the organisational change. The properties are described in a domain independent manner, more describing the global behaviour than the actual behaviour. Examples of domain specific variants can be found in Section 6.

RP(Change Manager):Unfreezing Organisation

if the Change Manager has a specification of how the organisation should be changed
and the Change Manager observes that conditions for initiation of the change are met
then the Change Manager unfreezes the organisation by informing the Members about the upcoming organisational change according to the change specification.

RP(Change Manager):Answer Questions

if the Change Manager receives a question from a Member about the upcoming organisational change
then the Change Manager provides an answer to that Member.

RP(Change Manager):Movement to New Organisation Form

if the Change Manager observes that all Member role instances have acknowledged the upcoming organisational change
then the Change Manager announces to the Member role instances when the organisational change will take place.

Mark Hoogendoorn, Catholijn M. Jonker, Martijn Schut, and Jan Treur

RP(Change Manager):Refreezing Organisation

if the Change Manager observes that the organisation behaves in a routine manner according to the change specification
then the Change Manager deactivates the Change Group.

The Members of the organisation together determine the behaviour of the organisation by virtue of the behaviour of their realising agents in their respective more specialised roles within the organisation (i.e., in their roles other than Member). The following properties specify how the information affects the behaviour throughout the organisation. Members are informed about the organisational change, based on that the agents realising the Member roles form a mental picture of the new organisation and their role in that new organisation, while still being conscious of their old roles in the organisation. Inter group interactions between the Member roles (in the Change Group) and the roles (existing, adapted or new) of the new organisation, will ensure that the new organisation takes effect.

RP(Member):Unfreezing Organisation

if a Member receives information from the Change Manager about an impending organisational change
and all questions that the Member posed to the Change Manager about this change have been answered by the Change Manager
then Member will send an acknowledgement to the Change Manager regarding the upcoming organisational change.

The following property is a schema of inter group interactions between the Member role instances of the Change Group and the roles (existing, adapted or new) of the new organisation. An instance of this scheme will exist for every pair consisting of a Member role instance and a role instance in the new organisation that have a realising agent in common.

GIP- schema(Member - Role):Movement

if a Member received from the Change Manager that the new organisation will take effect at time t
and the Member observes that it is time t
and Role received input relevant to Role
then Role produces output related to that input as specified in Role's role properties.

The organisational change is, therefore, realised because the agents realising the Member roles have the right image of the new organisation and their role in that new organisation and start behaving according to that image as soon as the agents know it is time to perform their roles in the new organisation.

4 A Specification Language for Organisations

In the previous section the basic outline of how organisational change can be described has been presented in an informal way. In order to be able to specify the changes that need to be performed there is a need for a formal way of describing the organisation. The description of an organisation can be divided into two parts. First, the structure of the organisation needs to be specified. This includes specifying the groups, roles and the links between them. The second element of the description is that of specifying the dynamics within the organisation. The dynamics are specified by means of the role properties, transfer properties, group properties, group interaction properties, and organisation properties. Languages for each of these two types of descriptions are introduced in this section.

4.1 The structural description of an organisation

As has been explained before, one of the necessities for specifying organisational change is that of specifying the structure. A language called *SL*, for Structural Language, is introduced here. The sorts that are used within this language are shown in Table 1. A description of the predicates within *SL* that can be used to specify the structure of the organisation is introduced in Table 2.

Table 1. Sorts in *SL*

Sort	Description
ROLE	Sort for a role within an organisation.
AGENT	Sort for an agent that can be allocated to a certain role.
GROUP	Sort for a group within an organisation.
TRANSFER	Sort for a connection between two roles within one group.
GROUP_INTERACTION	Sort for a connection between two roles in a different group.

As can be seen in Table 2, the structural specification is kept completely independent of the behavioural specification.

Table 2. Predicates defined in *SL* to describe the structure of an organisation

Predicate	Description
exists_role: ROLE	A role exists within an organisation.
allocated_to: AGENT x ROLE x GROUP	An agent is allocated to a role within a group.
exists_group: GROUP	A group exists within the organisation.
role_belongs_to_group: ROLE x GROUP	A role belongs to a group.
intra_group_connection: ROLE x ROLE x GROUP x TRANSFER	A role is connected to another role (directed) within a certain group by means of a transfer connection. The source and destination roles are allowed to be equivalent.
inter_group_connection: ROLE x GROUP x ROLE x GROUP x GROUP_INTERACTION	A role within a group is connected to a role within another group by means of a group interaction connection.

The use of the predicates is shown by means of the factory example which has been introduced in the previous section. The specification of the organisation would look like this (for the sake of brevity, only the details of the Change Group have been shown):

```

exists_group(ChangeGroup) ∧ existst_group(Group1) ∧
exists_role(ChangeManager) ∧ role_belongs_to_group(ChangeManager, ChangeGroup) ∧
exists_role(MemberOne) ∧ role_belongs_to_group(MemberOne, ChangeGroup) ∧
exists_role(MemberTwo) ∧ role_belongs_to_group(MemberTwo, ChangeGroup) ∧
inter_group_connection(MemberOne, ChangeGroup, RoleOne, Group1, g1) ∧
intra_group_connection(ChangeManager, MemberOne, ChangeGroup, t1)
⋮

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Following the example, Change Manager is present in the Change Group as well as Member One and Member Two. The roles within the group are fully connected, and in the specification there is one inter group connection, namely that of Member One within the Change Group and Role One within Group1.

4.2 The description of the dynamics within an organisation

The description of the dynamics within an organisation is another issue when wanting to specify an organisation. The properties of the organisation that determine these dynamics can be described using the *BL* language defined in Table 3. Two additional sorts have been used compared to the sorts used within *SL*, namely *DYNPROP*, denoting the name of a specific property, and *DYNPROPEXP* which is defined below.

Let Σ be a given set of state ontologies.

- (a) The set of *state properties* $\text{STATPROP}(\Sigma)$ is the set of all propositions over ground terms expressed in the ontologies from Σ .
- (b) Let L be a language for dynamic properties. The set of *dynamic properties* DYNPROPEXP_L is the set of formulae that can be formulated in language L with respect to traces based on the set of ontologies Σ .

In this case the subscript L can be dropped since a specific choice for Temporal Trace Language [7] has been made. The definitions of the different types of dynamic properties are more restricted than is shown in Table 3, therefore additional constraints need to be identified. For this, let ONT be a set of (state) ontologies, and O the organisation structure, $\text{ONT}(O)$ is defined as the set of ontologies within O . Accordingly, DYNPROPEXP can be defined as $\text{DYNPROPEXP}(O, \text{ONT}(O))$, stating that DYNPROPEXP is the set of all dynamic properties in O . Similar to this definition, given a role r , within a group g $\text{DYNPROPEXP}(\{r|g\}, \text{ONT}(r|g))$ is the set of dynamic properties of r . In case the set for the first argument within DYNPROPEXP contains only one element, the set signs are left out. This makes it possible to specify restrictions on the ontology that can be used for the specification.

Table 3. Predicates defined in *BL* to define the dynamics within an organisation

Predicate	Description
role_property: <i>DYNPROP</i> x <i>ROLE</i> x <i>GROUP</i>	A role within a group has a role property.
transfer_property: <i>DYNPROP</i> x <i>ROLE</i> x <i>ROLE</i> x <i>GROUP</i>	Within a group, a transfer property with an identifier holds between two roles.
group_property: <i>DYNPROP</i> x <i>GROUP</i>	A group has a certain group property.
group_interaction_property: <i>DYNPROP</i> x <i>ROLE</i> x <i>GROUP</i> x <i>ROLE</i> x <i>GROUP</i>	An interaction property with an identifier holds between two roles in different groups.
organisation_property: <i>DYNPROP</i>	A certain or property holds for the organisation.
has_expression: <i>DYNPROP</i> x <i>DYNPROPEXP</i>	A specific dynamic property has an expression.

The predicates that have been defined in Table 3 simply contain the necessary information that is needed to identify the party (or parties) of which the dynamics is specified. Based on the definition of the *DYNPROPEXP* it is possible to put more constraints on particular types of properties. The constraints for the different properties are defined in [8].

5 A Language for Dynamic Properties of Changing Organisations

An organisation model for organisation change as described informally in Sections 2 and 3, involves a number of issues:

- changing internal (belief) states of all those involved in the changing organisation
- changing organisation structure
- taking up new roles by agents
- internal state properties of the agents involved incorporate beliefs on organisation structure as well as beliefs on dynamic properties characterising role behaviour
- internal state properties (beliefs) play a role as part of the dynamic properties characterising role behaviour

A language to express dynamic properties of a changing organisation has to be a rich language able to express all these aspects in combination. Such a language is defined in this section as an extension of TTL [7]. Note that in this language not only dynamic properties are defined on top of state properties, but also state properties (in particular beliefs) are defined on top of dynamic properties. So it is possible to express a dynamic property built using a belief state property which itself refers to a dynamic property, and so on.

5.1 Sorts and Subsorts in TTL

Table 4. Sorts in TTL

Sort	Description
TRACE	for traces
STATE	for states within a trace.
T	time frame.
STATOMS	expressions for state atoms.
CONSTATOMS	expressions for conjunctions of state atoms.
STATPROPEXP	expressions for state properties.

The sorts that are included in TTL are shown in Table 4. The subsort relation $\text{STATOMS} \subseteq \text{CONSTATOMS}$ holds.

The function

and: $\text{CONSTATOMS} \times \text{CONSTATOMS} \rightarrow \text{CONSTATOMS}$

is used to build conjunctions of state atoms; it is also written as \wedge in infix notation

Furthermore, the relation $<: T \times T$ for time ordering is used, and the function

state: $\text{TRACE} \times T \times \text{PART} \rightarrow \text{STATE}$

that indicates the state of part of the considered system within a trace at some point in time.

For the changing organisation it is needed to use names and expressions for dynamic properties within other formulae. Therefore two sorts

DYNPROP names for dynamic properties

DYNPROPEXP expressions for dynamic properties

have been introduced in the previous section.

Moreover,

holds: $\text{STATE} \times \text{STATPROPEXP} \rightarrow \text{DYNPROPEXP}$

indicates the dynamic property that a state property expression is true in a state; this predicate holds is often written as \models in infix notation.

5.2 Building properties for the changing organisation

In a change process it is needed that the roles have beliefs about the organisation structure. Therefore all organisation structure representations described in Section 4 are included ; some examples are shown in Table 5,

Table 5. Examples of included organisation structure representations

exists_role :	ROLE \rightarrow STATPROPEXP
role_belongs_to_group:	ROLE \times GROUP \rightarrow STATPROPEXP
role_property:	DYNPROP \times ROLE \times GROUP \rightarrow STATPROPEXP
has_expression:	DYNPROP \times DYNPROPEXP \rightarrow STATPROPEXP
allocated_to:	AGENT \times ROLE \times GROUP \rightarrow STATPROPEXP

Moreover, to express beliefs, the following language construct is used :

belief: STATPROPEXP \rightarrow STATPROPEXP

An example of its use is: belief(exists_role(s) \wedge role_belongs_to_group(s, g))

Furthermore it is needed that the roles have beliefs about the behavioural properties that are expected from a certain role. Therefore first a representation

leads_to: CONSTATOMS \times CONSTATOMS \rightarrow DYNPROPEXP

is introduced for a simple type of such properties. A more general type of dynamic property is built using:

$\&$: DYNPROPEXP \times DYNPROPEXP \rightarrow DYNPROPEXP

and similarly for other logical connectives such as not, \Rightarrow , \forall , \exists .

Thus within the sort DYNPROPEXP two types of expressions are built:

- temporal statements based on atoms of the form $\text{state}(\gamma, t, P) \models p$ for state properties p
- leads to statements of the form $\text{leads_to}(V, W)$ with V and W conjunctions of atoms

Although the latter type of expressions can be mapped to (are definable in terms of) the former type of expressions, for simplicity they are kept separate.

An example of an expression that can be built using the constructs above is the following

$$\begin{aligned} &\exists t \text{ state}(\gamma, t, \text{internal}(r)) \models \\ &\text{belief}(\text{exists_role}(s) \wedge \text{role_belongs_to_group}(s, g)) \wedge \\ &\text{belief}(\text{role_property}(d1, s, g)) \wedge \\ &\text{belief}(\text{has_expression}(d1, \text{leads_to}(a \wedge b, c))) \end{aligned}$$

This expression states that

there will be a time that

within role r there is the belief that

the organisation structure includes role s in group g , and

this role has dynamic property $d1$ which is expressed by $\text{leads_to}(a \wedge b, c)$.

So on the top level this is a dynamic property built on state properties (the beliefs), which themselves refer to state properties concerning the organisation structure and to

a dynamic (leads to) property again. Another example property is the following, describing that a role performs the behaviour it believes that is expected from the role:

$$\begin{aligned}
 & [\text{state}(\gamma, t, \text{internal}(\text{RegHead})) \models \text{belief}(\text{role_property}(d, \text{RegHead}, \text{RegGroup1})) \wedge \\
 & \text{belief}(\text{has_expression}(d, \text{leads_to}(v, w))) \\
 & \& \text{state}(\gamma, t, \text{input}(\text{RegHead})) \models v] \\
 & \Rightarrow \exists t' \geq t \text{ state}(\gamma, t', \text{output}(\text{RegHead})) \models w
 \end{aligned}$$

6 Simulation of the Case Study: the Eleven Cities Tour example

The organisation model of organisational change has been applied to the organisation that is responsible for the famous Frisian skating tour called the Eleven Cities Tour. The association is called “De Friesche Elf Steden” in Dutch. On the basis of that model a simulation has been constructed. In this section some relevant parts of the model and of the simulation are discussed.

Although the association has fixed parts in the organisation, it also has an annual dynamics in its structure. The association has a board consisting of 9 members that has two responsibilities: running the association smoothly at all times and organising the tour. Most of the year only the board is active. Once a year, at the beginning of winter, the annual members’ meeting is held with the usual agenda items as any association, e.g., the financial status (balance-sheet), report of the activities, the number of members of the association, election of new board members. However, the association also always has one additional agenda item: the election of Region Heads for the coming winter season. The Region Heads are responsible for monitoring the condition of the ice along a specific stretch of the Tour. During meetings of a group called the Meeting of Region Heads, in which representatives of the Board and of the Region Heads are members, the condition of the ice along the route of the Tour are discussed, and if favourable, a Tour is organised. When the winter is over, these parts of the organisation are dismantled again until next year’s winter. So, in summary, through spring, summer and autumn (the off-season) the association only consists of its members and its board.

The organisation of the Eleven Cities tour example is shown in Figure 3. In the model there are two permanent groups, i.e., the Board and the Annual Meeting group. The Board consists of the usual roles like Chair, Treasurer, Secretary, and a number of Members of the Board. The Annual Meeting group consists of a Chair, representatives of the Board and a number of Participants. The Board is active throughout the year, the Annual Meeting is active only once each year. The Chair of the Annual Meeting is typically (but not always) allocated to the agent that also realises the Chair role of the Board. Similar relations apply to Board Members and Board Representatives in the Annual Meeting.

In this particular example, the changes made to the organisation are made every year, so that each agent involved in the association knows what Region Heads are supposed to do, and knows the dynamics of the annual organisational change. In the model the Annual Meeting group is responsible for organising and managing the creation of the Region Head role and of the Meeting of Region Heads group. That means that the organisational change requires nothing more than the Chair of the

Annual Meeting announcing that it is time to form the Region Head role and the Meeting of Region Heads group and to assign agents to the instances of Region Head role and to the roles within the Meeting of Region Heads.

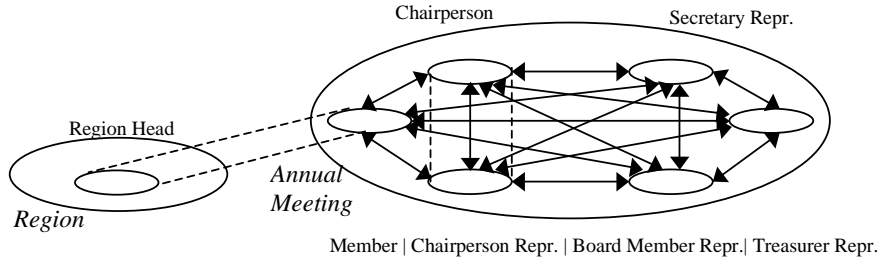


Fig. 3. The structure of the Eleven Cities Tour organisation just after the formation and allocation of the regions

The organisation structure after the creation of the Region Heads is identical to the situation described in Figure 3. The Region group consists of more roles than the Region Head role (Monitor roles), however these roles have been left out of the figure for the sake of clarity.

Once Region Heads have been appointed, they start their work of monitoring the ice condition along the route. The Chair of the newly created Meeting of Region Heads (typically assigned to the same agent that is also Chair of the Board) activates that group (i.e., holding a meeting) at appropriate moments (certainly when it has been freezing properly for a two week period). If the conditions are good, this group organises the Tour. At the end of the winter, the Chair of the Meeting of Region Heads thanks all participants and deactivates all roles in that group as well as all Region Head role instances. By the decision of the Annual Meeting group, at this point in time the agents are de-allocated from their roles, and the roles immediately cease to exist. The involved agents only remain allocated to the continuous roles / roles instances in the Board and Annual Meeting group.

The properties (in executable format) that have been used for the simulation of the model are omitted for the sake of brevity. For the specification of organisational behaviour the approach presented in [2] has been adopted, which is based on AGR. In Figure 4, a partial trace of the simulation is shown. The figure shows the input and output atoms of the Chair (represented by the Change Manager in the trace) during the Annual Meeting (denoted as Change Group) and the atoms belonging to the Region Head of Woudsend as this clarifies the working of the organisation model as presented before. It also shows the final decision that the tour will be organised. Behind the atoms the truth values are presented, a black area represents the period in which an atom is true, a grey area stands for the atom being false. More specifically, it is shown how around time point 5 by the atom

```
inform(change_process_in_progress(local_organisation))
```

the Change Manager informs the Members of the Change Group that a change process concerning the local organisation (i.e., the region group structures) is starting to be in

Modelling the Organisation of Organisational Change

progress. This starts the unfreezing phase for the local organisation. After this all Members of the Change Group inform the Change Manager that they are prepared for this change by telling their beliefs of the form, e.g.,

```
belief(change_process_in_progress(local_organisation), MemberOne, ChangeGroup)
```

After having received this for all of them the Change Manager considers the unfreezing phase for the local organisation successfully finished and starts the movement phase for the local organisation by informing all Members of the Change Group that the region structure is in effect:

```
inform(region_structure)
```

After having received the information that the Members believe that the region structure is in effect, the Change Manager starts the allocation of agents to the Region Head roles.

```
request_candidates_for_regions
```

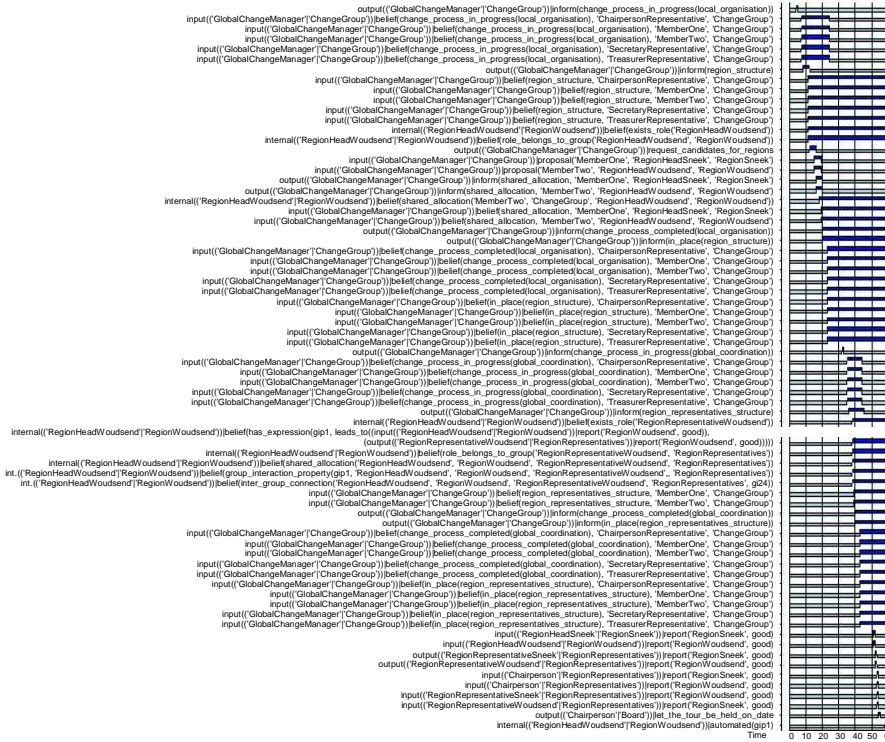


Fig. 4. Partial trace of the simulation of the Eleven Cities Tour

After having received proposals for candidates the Change Manager appoints the subsequent Member role instances to the proposed RegionHead instances by, e.g.,

```
inform(shared_allocation, 'MemberOne', 'RegionHeadSneek', 'RegionSneek')
```

Notice that here by means of the Member role the underlying agent is addressed who is to take up the role of RegionHead. This is a way to stay within the organisation model with the process of allocation and not step outside the organisation model to address agents by a communication between a role and an agent, which from a modelling perspective would be undesirable. This is possible here since all the agents already take part in the organisation and the in the change process. After the respective Members have acknowledged that now they believe they have a shared allocation with the RegionHead roles, the Change Manager considers the movement phase for the local structure finished (time point 20):

```
inform(change_process_completed(local_organisation))
```

Moreover, at the same time point the Change Manager starts the refreezing phase for local organisation by

```
inform(in_place(region_structure))
```

After the Members have acknowledged that now they believe the new structure is in place, the refreezing process is considered finished.

A second cycle of unfreezing, movement and refreezing concerns organisation of the coordination of all local Region Groups. This cycle starts after the weather has shown a period of frost. Similar to the above cycle

```
inform(change_process_in_progress(global_coordination))
```

starts the unfreezing process (between time points 30 and 35), communication of

```
belief(change_process_in_progress(global_coordination), 'MemberOne', 'ChangeGroup')
```

indicates the end of the unfreezing phase for the global coordination organisation change, and

```
inform(region_representatives_structure)
```

indicates the start of the movement phase. Shared allocations are made of RegionHeads and RegionRepresentatives, this time not by explicit appointment by the Change Manager, but more implicitly, by the internal beliefs in the RegionHead roles that, as part of the new organisation structure, every RegionHead role has a shared allocation with a RegionRepresentative role

```
belief(shared_allocation('RegionHeadWoudsend', 'RegionWoudsend',  
'RegionRepresentativeWoudsend', 'RegionRepresentatives'))
```

After having received communication of

```
belief(region_representatives_structure, 'MemberOne', 'ChangeGroup')
```

by the Change Manager the end of the movement phase and start the refreezing phase are indicated at time point 40:

```
inform(change_process_completed(global_coordination))  
inform(in_place(region_representatives_structure))
```

Between time points 40 and 55, the organisation structure as a whole has been functioning, thereby automating the behaviours for the roles. In particular *gip1* is the name of a group interaction property of the pair of roles <RegionHead, RegionRepresentative> which has been automated, indicated by an internal state property

```
automated(gip1)
```

of both roles. This is the end of the refreezing phase of the second cycle of organisational change.

7 Verification of the Case Study Simulation

As for verification of the organisation process of the Eleven Cities Tour is concerned, a distinction is made between two types of verification. Firstly, guarantees are given that concern the tour itself. For example, if the circumstances permit so (if the ice is thick enough over the whole trajectory) then a tour should be organised. Secondly, guarantees on the organisation of organisational change for setting up the tour are verified. This happens by means of the annual meeting, appointing region heads, ice monitors etcetera. This Section presents both verification types. For the organisation of organisational change, the change model of Lewin as presented in the introduction is adopted.

7.1 Content Properties

The overall goal of the Eleven Cities Tour organisation is to arrange for a tour to be organised when possible, i.e., when the ice along the tour is thick enough to ensure a safe passage. The following property expresses this goal.

OP1 (semiformal)

If the ice conditions in all regions are good, then it is announced that the tour will be held.

This property has been checked against the simulation trace that was presented in Section 6. For reasons of space limitation only OP1 is addressed in this paper.

7.2 Organisational Change Properties

The properties as presented in the previous Section depend on some organisational structure to ensure the fulfilment of each property and all of them combined. For this purpose, the aim of this paper is exactly this: a way to specify and model such an organisation itself has been presented, as well as the actual process of setting up the organisation. As such, this organisation can support the organisational properties as presented above.

This Section presents the formalisation of milestone properties concerning the change process itself - called unfrozen, moved and refrozen, respectively. For the moved and refrozen properties, the formation of groups is considered on the one hand and roles taking up some behaviour on the other hand. The presented properties have been checked against the simulation trace presented in Section 6.

7.2.1 Unfrozen As explained in the introduction, most importantly in the unfreezing process is raising awareness of everyone concerned on the upcoming change. This means here that when the annual organisational change has been announced, eventually all concerned are aware of this.

OP_unfrozen (semiformal)

If it has been announced that a change process is in progress, then at some later moment all members concerned have communicated that they are aware of this.

Note that the organisational structure is only represented internally to the role (by means of beliefs) and not as an external entity. Therefore in the abovementioned property we consider the beliefs of the GlobalChangeManager for identifying the roles that are in the ChangeGroup.

7.2.2 Moved The movement process in our example breaks up into two parts. The first one concerns setting up groups that are to be formed (e.g., region representatives), the second part concerns raising the awareness with everyone concerned of behaviours of new roles (how to be a good region representative). For both parts, the movement process is considered to be completed when all members are aware of the new groups and related role behaviours. Actually acting upon these new groups and roles happens afterwards in the refreezing process.

The newly-formed groups are announced and taken up (believed) by everyone concerned. The following property captures this idea.

OP_moved_group (formal)

```

 $\forall \gamma, t, \text{struct}:\text{GROUP\_STRUCT} :$ 
 $\text{state}(\gamma, t, \text{output}(\text{GlobalChangeManager}|\text{ChangeGroup})) \models \text{inform}(\text{struct})$ 
 $\Rightarrow$ 
 $\exists t' > t, \forall r:\text{ROLE} :$ 
 $[ \text{state}(\gamma, t, \text{internal}(\text{GlobalChangeManager}|\text{ChangeGroup})) \models \text{belief}(\text{exists\_role}(r))$ 
 $\&$ 
 $\text{state}(\gamma, t, \text{internal}(\text{GlobalChangeManager}|\text{ChangeGroup})) \models$ 
 $\text{belief}(\text{role\_belongs\_to\_group}(r, \text{ChangeGroup})) ]$ 
 $\Rightarrow$ 
 $\text{state}(\gamma, t', \text{input}(\text{GlobalChangeManager}|\text{ChangeGroup})) \models$ 
 $\text{belief}(\text{struct}, r, \text{ChangeGroup})$ 

```

This property assumes that everyone in the ChangeGroup is informed about the new groups. In the simulation trace, this is not the case for both new groups that are introduced. For the region structure group, it is the case and the property succeeds. However, for the region representative group this is not the case (only members are informed who are going to be region heads) and this property thus fails.

As for the newly introduced roles in the movement process, upon completion all concerned are aware of the behaviours of these new roles. For illustrative purposes, in the simulation trace this has only been formalised for the new role of the Woudsend region head.

OP_moved_role (formal)

```

 $\forall \gamma, t, r, r':\text{ROLE}, g, g':\text{GROUP} :$ 
 $(\text{state}(\gamma, t, \text{internal}(r, g)) \models \text{belief}(\text{shared\_allocation}(r, g, r', g'))$ 
 $\&$ 
 $\text{state}(\gamma, t, \text{internal}(\text{GlobalChangeManager}|\text{ChangeGroup})) \models$ 
 $\text{belief}(\text{role\_belongs\_to\_group}(r, \text{ChangeGroup})))$ 
 $\Rightarrow$ 
 $\exists t' \geq t, \text{dyn}:\text{DYNPROP}, \text{dynex}:\text{DYNPROPEXP} :$ 
 $[ (\text{state}(\gamma, t', \text{internal}(r, g)) \models \text{belief}(\text{group\_interaction\_property}(\text{dyn}, r, g, r', g')) \text{ or}$ 
 $\text{state}(\gamma, t', \text{internal}(r, g)) \models \text{belief}(\text{role\_property}(\text{dyn}, r, g, r', g')) \&$ 
 $\text{state}(\gamma, t', \text{internal}(r, g)) \models \text{belief}(\text{has\_expression}(\text{dyn}, \text{dynexp})) ]$ 

```


7.2.3 Refrozen In refreezing, the new organisational structure is actually implemented enabling its execution. For groups, this means that the new lines of communication can now be brought into practice. For roles, it means that the behaviour moves from knowledge of knowing about the behaviour and consciously performing it to the level of automatically exhibiting the desired behaviour.

OP_refrozen_group (formal)

```

 $\forall \gamma, t, \text{struct:GROUP\_STRUCT} :$ 
state( $\gamma, t$ , output(GlobalChangeManager|ChangeGroup)) |= inform(in_place(struct))
 $\Rightarrow \exists t' \geq t, \forall r:\text{ROLE} :$ 
[ state( $\gamma, t$ , internal(GlobalChangeManager|ChangeGroup)) |= belief(exists_role(r))
&
state( $\gamma, t$ , internal(GlobalChangeManager|ChangeGroup)) |=
belief(role_belongs_to_group(r, ChangeGroup)) ]
 $\Rightarrow$ 
state( $\gamma, t'$ , input(GlobalChangeManager|ChangeGroup)) |=
belief(in_place(struct), r, ChangeGroup)

```

OP_refrozen_role (formal)

```

 $\forall \gamma, t, r, r':\text{ROLE}, g, g':\text{GROUP}, \text{dyn:DYNPROP}, \text{dynex:DYNPROPEXP} :$ 
[ (state( $\gamma, t'$ , internal(r,g)) |= belief(group_interaction_property (dyn, r, g, r', g')) or
state( $\gamma, t'$ , internal(r,g)) |= belief(role_property (dyn, r, g, r', g'))) &
state( $\gamma, t$ , internal(r,g)) |= belief(has_expression(dyn, dynexp)) ]
 $\Rightarrow \exists t' \geq t : \text{state}(\gamma, t, \text{internal}(r, g)) \models \text{automated}(\text{dyn})$ 

```

8 Conclusions

Organisations often have to survive in a dynamic world. To enable organisations in practice to adapt to the dynamics of the world, certain facilities, structures and capabilities are needed that support organisational change. This paper shows how the organisation of organisation change processes can be modelled within a formal organisation modelling approach. A generic organisation model for organisational change was presented and formally verified for a case study concerning the organisation of a major event in the Netherlands: the eleven cities tour. The formal verification sets it apart from existing work on organisation modelling, e.g., [3] [13]. Previous work of the authors on organisational change [9] considered change as an instantaneous event instead of a process of change as we do this paper. Additionally, previous work did not include the distinction between formal languages for expressing the change process. The change model in this paper takes into account different phases in a change process (unfreezing, movement and refreezing) considered in [10], see also [12] [11]. In change processes the internal (mental) states of those involved in the organisation are important. Therefore, also internal states of individuals have to be part of a model for organisational change. In particular, beliefs and their changes have been incorporated in the model. In addition also a distinction was made between automated and non-automated (more conscious) role behaviour. For the latter case an internal model for (reflective) reasoning about expected role behaviour was included. Hence, a model was created that combines organisation aspects and cognitive aspects.

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